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TEST EFFECTIVENESS TREND OBSERVATION

Effectiveness of Vacuum Environment in the Thermal/Vacuum Test

CONCLUSION:

The presence of a vacuum during thermal testing of hardware is a significant factor in the effectiveness of the thermal test as a screen for detecting hardware defects.

DISCUSSION:

A survey was made of the problem/failure reports (PFRs) written during assembly-level and system-level thermal/vacuum (TV) tests performed for the Voyager and Galileo pro ects (pre-1986). One of the ob ectives of this study was a determination of the necessity of a vacuum environment along with an elevated temperature for uncovering problem/failures.

Assembly level TV qualification tests are performed at +75 and -20°C and at pressures less than or equal 10^{-5} Torr. The time duration spent at high temperature is 144 hours (prior to Voyager and Galileo it was 288 hrs) and at low temperature is 24 hours. Assembly-level flight acceptance TV testing is done at +55 and 0°C. The time spend at high and low temperature is 60 hours and 8 hours respectively. The assembly-level TV test is generally performed after dynamic environments tests and preceding the EMC test which is performed last.

The system-level TV environmental tests are intended to be responsive to thermal operational conditions at flight limits with a small margin. The test duration for Voyager was a total of 261 hours for the proof test module, including a thermal design verification and a qualification test, and 99 and 108 hours, respectively for the FA test for the two flight S/C. For Galileo the duration of the thermal design verification was 260 hours, and the duration of the protoflight and FA tests combined was 144 hours. The system-level TV test occurs last in the environmental test sequence.

An attempt was made to differentiate between problems detected as a result of the TV test, but that were initiated during earlier tests in the sequence, from problems occurring during the TV test in spite of the earlier testing, and rework and retesting that followed. The latter category of problems is dependent on unique problem-finding characteristics of TV testing.

The necessity of a vacuum during thermal testing requires a two fold consideration. First, where the anomaly was purely temperature induced, the existence of vacuum is a contributor to a higher temperature then would have occurred in an ambient-pressure temperature test due to producing a proper temperature distribution (The absence of gaseous conduction and convective effects - an effect which can approach 20°C at the part level). Second, there are those cases where vacuum directly contributed to the cause of the anomaly. Included in the latter class of problems are materials degradation problems, including oily

deposits, blistering, debonding and delamination, buckling, lubrication problems, component shorting, pressure loss, thin film rupturing, and sticking covers.

Tables 1 and 2 provide the TV environment results and list the total number of anomalies occurring during TV testing. The rows in respective order list the number and percentage of the P/Fs that either required: (1) only temperatures at ambient pressure, (2) temperatures under vacuum, and (3) vacuum alone. Rows 4 and 5 indicate respectively the number and percentage where the dependency was undetermined and where the problem was not due to temperature or vacuum. The tables show that with the exception of the Galileo system-level TV about 70 percent of the total number of anomalies that occurred during TV test depended on the presence of a vacuum environment and about 49 percent of the anomalies that occurred during the Galileo system-level TV test depended on the presence of a vacuum environment.

Table 1. Assembly-Level TV Test

PROGRAM	VOYAGER		GALILEO	
DEPENDENCY	NUMBER	PERCENT	NUMBER	PERCENT
Number where temperature only required	9	19.6	7	19.4
Number where temperature & vacuum both required due to influence of vacuum on temperature	10	21.7	17	47.2
Number where vacuum alone required	21	45.7	8	22.2
Number where dependency was undetermined	4	8.7	3	8.3
Number where none of the specified environments was required	2	4.3	1	2.8
TOTALS	46	100	36	100

Table 2. System-Level TV Test

PROGRAM	VOYAGER		GALILEO	
DEPENDENCY	NUMBER	PERCENT	NUMBER	PERCENT
Number where temperature only required	0	0	4	10.3
Number where temperature & vacuum both required due to influence of vacuum on temperature	6	13	5	12.8
Number where vacuum alone required	29	63	14	35.9
Number where dependency was undetermined	2	4.3	2	5.1
Number where none of the specified environments was required	9	19.6	14	35.9
TOTALS	46	100	39	100